International Space Station Program Overview

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Manager, ISS Program

November 2012

ISS Program Restructure

- **The ISS achieved assembly complete in 2011. With assembly tasks completed, the ISS Program took the opportunity to fine tune its organizational structure to better focus on achieving the full scientific capabilities of the ISS.**
- **Previously, all utilization aspects were managed within one office. This included managing the needs of utilization customers, managing the utilization hardware and software facilities on-orbit and managing the day-to-day utilization activities on-orbit.**
- **The ISS organizational deployment now:**
  - The Utilization Office (OZ) remains the steward of the utilization customers needs ensuring they are integrated into the appropriate ISS processes that yield utilization results in the shortest life cycle time possible.
  - The Vehicle Office (OB) now maintains all hardware on-board the ISS including utilization hardware which allows for greater efficiency in planning and executing maintenance and repair with a priority on utilization.
  - The Avionics and Software Office (OD) now maintains all avionics and software related services needed for the execution of utilization on-board which allows for greater efficiency in planning and executing avionics and software maintenance with a priority on utilization.
  - The Mission Integration Office (OC) now plans and executes all on-orbit activities which allows for greater efficiency in planning and executing operations and responding to anomalies in daily activities with a priority on utilization.

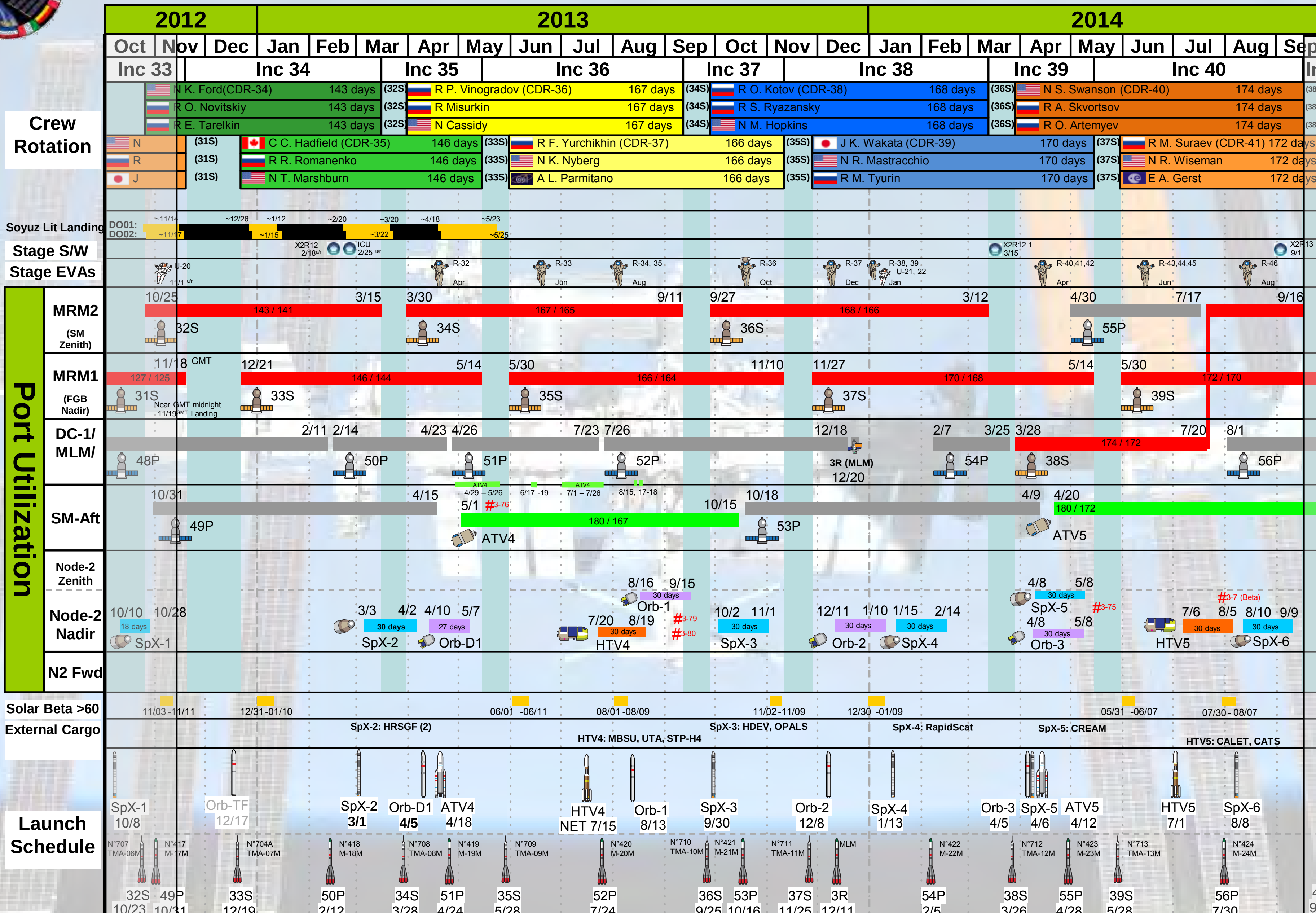
For current baseline refer to SSP 54100 Multi-Increment Planning Document (MIPD)

ISS Flight Plan

Flight Planning Integration Panel (FPIP)

NASA Official: John Coggeshall
Prepared by: Scott Paul

Chart Updated: November 13th, 2012
SSCN/CR: 13526 (Baseline)



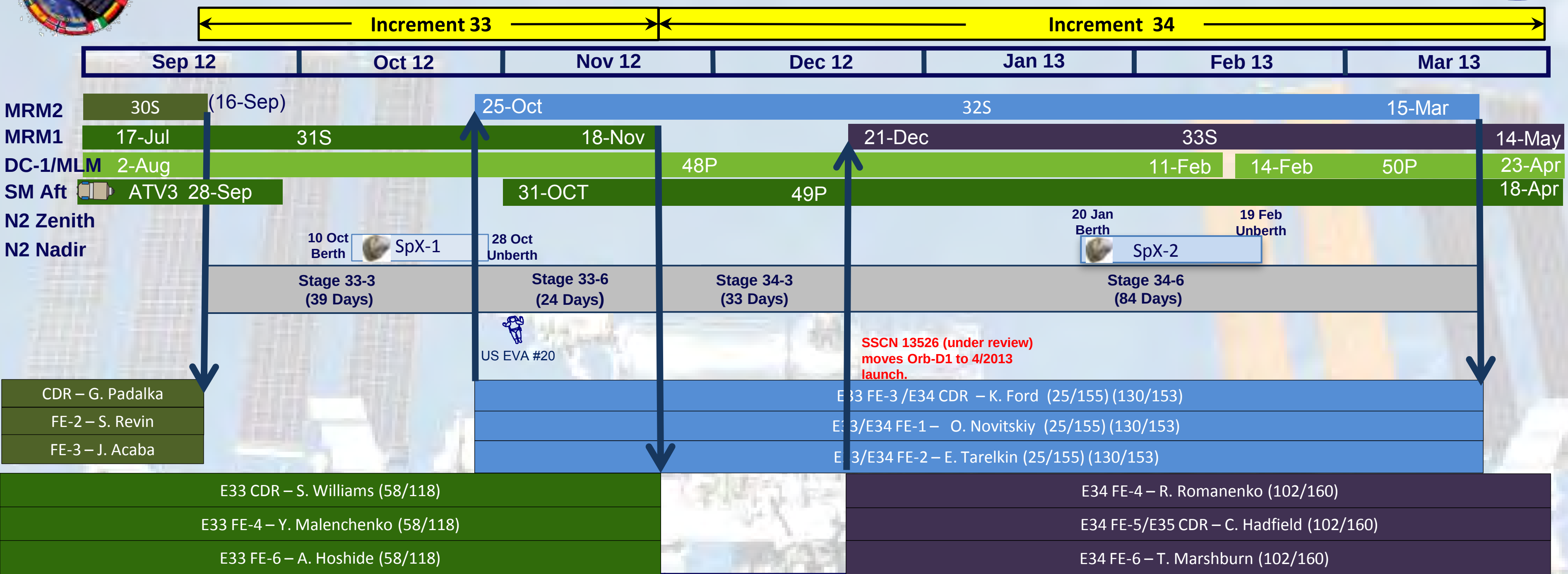
Expedition 33 Overview

Akihiko Hoshide
Yuri Malenchenko
Sunita Williams – Exp 33 CDR
(Soyuz TMA-05M)

Evgeny Tarelkin
Oleg Novitskiy
Kevin Ford – Exp 34 CDR
(Soyuz TMA-06M)

INCREMENTS 33 & 34

Updated October 24, 2012



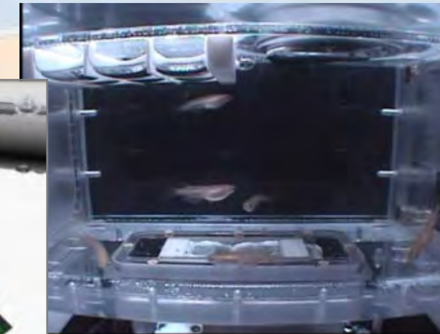
	Stage 33-3	Stage 33-6	Stage 34-3	Stage 34-6
Vehicle Traffic	✓ Berth SpX-1 ✓ Prep for 32S arrival ✓ Prep for ATV3 undock	• Dock 32S & 49P • Undock 31S • Prep for 49P arrival • Unberth SpX-1	• Prep for 33S arrival • Prep for Orb-D1 arrival	• Dock 33S & 50P • Undock 32S & 48P • Unberth Orb-D1 • Berth & Unberth SpX-2
Utilization	✓ Energy (E) ✓ Circadian Rhythms (E) • MSPR Commissioning–AQH (J) • Integrated Cardiovascular (N) ✓ Sprint (N) ✓ VO2Max (N) ✓ ACE-1 (N)	• Reversible Figures (E) • Thermolab (E) • Resist Tubule (1st time, J) • Hicari (J) • Pro-K (N) • Elite-S2 (N) • InSPACE-3 (N) • Micro-6 (1st time, N) • *Medaka Osteoclast1* (1st time, J)	• SOLAR (E) • TRITEL (1st time, E) • Nano Step (J) • NanoRacks (N) • MDCA / FLEX-2 (N) • I-SERV (1st time, N) • RRM (N)	• SOLAR (E) • Microflow 1 (1st time, C) • RADI-N2 (1st time, C) • IMMUNO (E) • MARES c/o (E) • EPO10 / ED-Blue Earth Gazing (1st time, J) • Spinal Ultrasound (1st time, N) • Seedling Growth-1 (1st time, N) • CSLM-3 (N) • Cell Bio Tech Demo (1st time, N) • NLP Vaccine-18&21 (N)
EVA, Resupply & Outfitting and Maintenance		• Calibrate IPOMs • USOS EVA#20 – bypass PVTCS Radiator		• JEMRMS SFA Ground control demo • SPCU Heat Exchanger R&R
Software / Avionic Updates	✓ Node CDRA Air Seletor Valve R&R ✓ OGA ACTEX Pre-flush & R&R	• UPA 6.2 transition		• Transition to iAPS 6.3 and X2R12 • Ku-Band Comm Sys (ICUs 1&2) install & c/o • Install & C/O Columbus HDVCA • Nodes 1 & 2 WAP swap • WPA firmware upgrade • Convert APSs to iAPS spares

Expeditions 33 & 34 Objectives

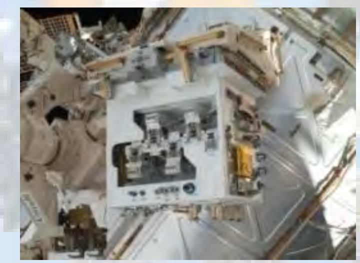
(September 2012 – March 2013)

- **Perform a minimum average of 35 hrs/week for payload investigations**
- **Perform first time payload operations of Robotic Refueling Mission (RRM) fluid transfer, deploy and activate JAXA Small Satellite Orbital Deployer (J-SSOD) and then Cubesat** (completed) **commission JAXA Aquatic Habitat for first use - *Medak*a (fish) osteoclast**
- **Execute ESA SOLAR full sun rotation viewing**
- **Perform demonstration of ground control of JEM RMS Small Fine Arm (SFA)**
- **Perform SpaceX-1** (completed)**, SpaceX-2 and Orbital-Demo1 rendezvous and berthing, attached operations, unberthing and departure**
- **Perform SpaceX, Orbital, Soyuz & Progress cargo operations**
- **Perform ATV-3 undock operations** (completed)
- **Complete Russian vehicle operations including 32-Soyuz and 33-Soyuz docking; 31- and 32-Soyuz undock and landing; 48- and 50-Progress undocking; and 49-, 50- and 51-Progress docking**

J-SSOD



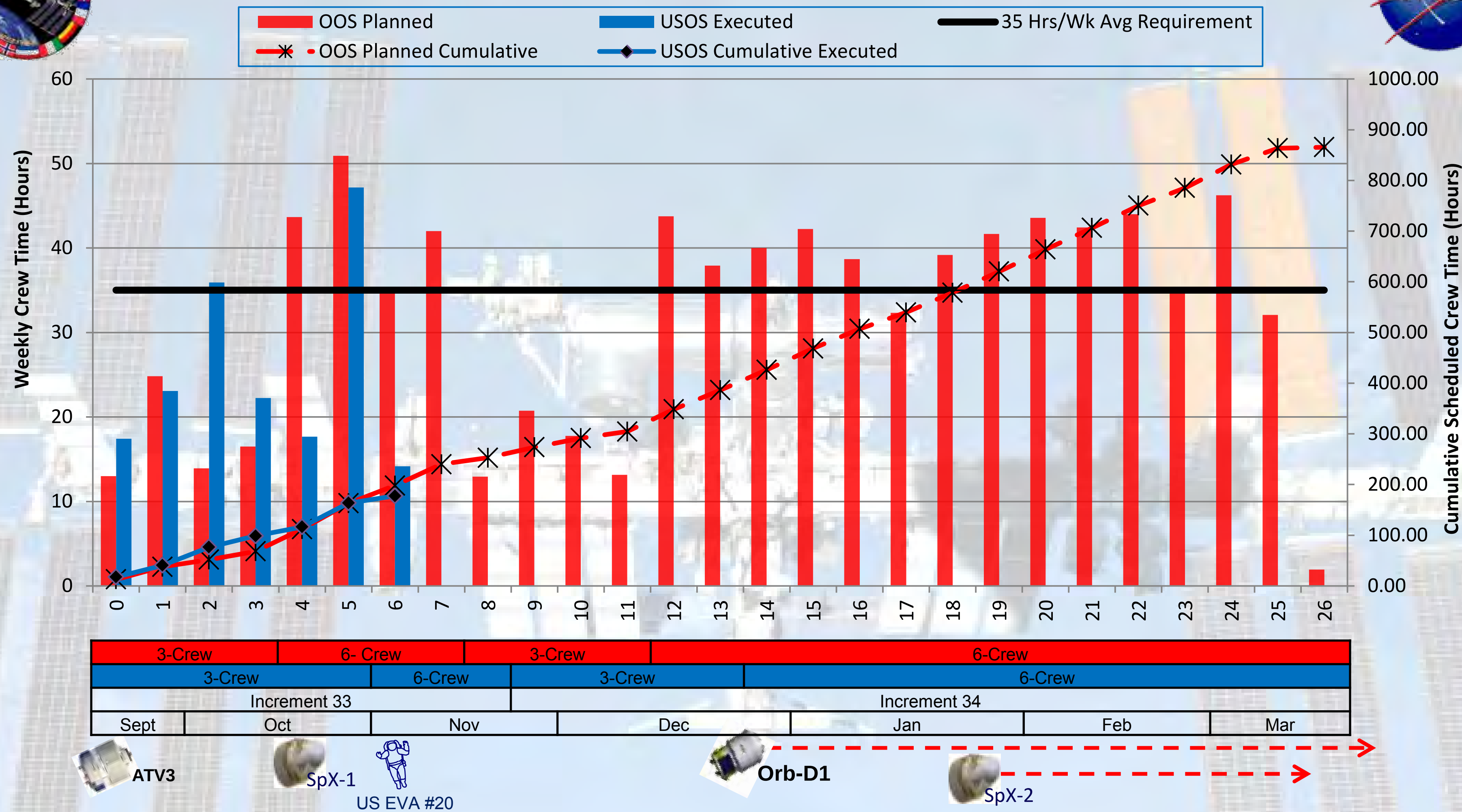
Aquatic Habitat



Robotic Refueling Mission

Space-X Dragon capsule approaching and berthed to the ISS

Increment 33_34 Utilization Crew Time



OC/OZ reconciliation is complete through Week 6.

Executed through Increment Wk (WLP week) 6 = 6.8 of 25.8 work weeks
26.36 % through the Increment

USOS IDRD Allocation:	868.0	hours
OOS USOS Planned Total:	865.5	hours
USOS Actuals:	177.68	hours
	20.5	% through IDRD Allocation
	20.5	% through OOS Planned Total
Total USOS Average Per Work Week:	26.13	hours/work week
Voluntary Science Totals to Date:	4.25	hours (Not included in the above totals or graph)

Total ISS Consumables Status: Total On-orbit Capability
18-October-12 49P SORR, 49P (Dock 2-Nov-12)

	T1: Current Capability with no resupply		T2: Current Capability with 49P	
Consumable – based on current, ISS system status	**Date to Reserve Level**	**Date to zero supplies**	**Date to Reserve Level**	**Date to zero supplies**
Food – 100% (1)	May 11, 2013	July 2, 2013 **(2)**	June 24, 2013	August 8, 2013
KTO	March 29, 2014	May 13, 2014	May 23, 2014	July 10, 2014 **(2)**
Filter Inserts	July 4, 2014	August 18, 2014	August 18, 2014	October 10, 2014 **(2)**
Toilet (ACY) Inserts (2)	February 27, 2014	April 21, 2014	April 2, 2014	May 21, 2014
EDV (UPA Operable) (3) (4)	May 11, 2013	July 29, 2013 **(2)**	June 12, 2013	August 23, 2013
Consumable - based on system failure				
EDV (UPA Failed) (2) (3)	February 20, 2013	April 14, 2013	March 1, 2013 March 18, 2013	May 28, 2013
Water, if no WPA (Ag & Iodinated) (5)	April 27, 2013	June 18, 2013 **(2)**	June 7, 2013	July 22, 2013
O_2 if Elektron supporting 3 crew & no OGA (2) (6)	March 6, 2013	August 1, 2013	April 3, 2013	August 14, 2013
O_2 if neither Elektron or OGA (6)	December 9, 2012	February 12, 2013 **(2)**	December 22, 2012	February 19, 2013
LiOH (7) (CDRAs and Vozdukh off)	**Dock Dates:** ~ 5.8 days	**32S / 25-OCT-12** ~19.8 days	**49P / 2-NOV-12** ~ 5.8 days	~19.8 days

(1) Includes food on Soyuz; after RS goes to zero, both sides share USOS food. **(2)** Reserve level to Zero is different than 45 days due to varying crew size. **(3)** Progress tanks included in assessment for urine dumping only. ATV tanks included in assessment for urine and brine dumping. **(4)** A-RFTA operations as of 8/6/12. Assumes 74% recovery rate and no RS urine processing. **(5)** RS processes all condensate in event of WPA failure. **(6)** Includes metabolic O2 for 45 day/6-crew reserve and the O2 for greater of CHeCs or 4 contingency EVAs. **(7)** LiOH Canisters will be used for CO2 removal from the ISS if the CDRAs are inoperable. Total LiOH Reserve Level is 14 days for 6 crew. (Reserve Level for USOS LiOH is ~13.3 days for 3 crew (20 canisters), and for RS LiOH is 15 days for 3 crew (15 canisters).)

USOS ISS Consumables Status: USOS On-orbit Capability
18-October-12 49P SORR, 49P (Dock 2-Nov-12)

	U1: Current Capability with no resupply		U2: Current Capability with 49P	
Consumable – based on current, ISS system status	**Date to Reserve Level**	**Date to zero supplies**	**Date to Reserve Level**	**Date to zero supplies**
Food – 100% (1)	September 17, 2013	November 3, 2013 **(2)**	September 23, 2013	November 7, 2013
KTO	June 20, 2015	August 4, 2015	June 20, 2015	August 4, 2015
Filter Inserts	July 17, 2015	August 31, 2015	July 17, 2015	August 31, 2015
Toilet (ACY) Inserts (2)	March 25, 2015	May 11, 2015	March 25, 2015	May 11, 2015
EDV (UPA Operable) (2) (3) (4)	July 13, 2013	January 29, 2014	July 13, 2013	January 29, 2014
Consumable – based on system failure				
EDV (UPA Failed) (3)	December 25, 2012	February 8, 2013	December 25, 2012	February 8, 2013
Water, if no WPA (Ag & Iodinated) (2)	March 9, 2013	April 28, 2013	March 9, 2013	April 28, 2013
O_2 if no OGA (2) (5)	January 14, 2013	April 2, 2013	January 14, 2013	April 2, 2013
LiOH (6) (CDRAs off)	~11.3 days	~24.6 days	~11.3 days	~24.6 days

Dock Dates: **32S / 25-OCT-12** **49P / 2-NOV-12**

(1) Includes food on Soyuz. **(2)** Reserve level to Zero is different than 45 days due to varying crew size. **(3)** Progress tanks not included in assessment for urine dumping. ATV tanks are included in assessment for urine and brine dumping. **(4)** A-RFTA operations as of 8/6/12. Assumes 74% recovery rate and no RS urine processing. **(5)** Includes metabolic O2 for 45 day/3-crew reserve and the O2 for greater of CHeCs or 4 contingency EVAs. **(6)** LiOH Canisters will be used for CO2 removal from the ISS if the CDRAs are inoperable. Reserve Level for USOS LiOH supplies is ~13.3 days for 3 crew (20 canisters).

USOS Challenges (1 of 3)

- **DC Switching Unit (DCSU) 3A Remote Bus Isolator (RBI) 1**
  - Currently operating nominally. Tripped on 9/1/12, observed (negative) current flowing from the DCSU toward the SSU. Hindsight buffer showed a fault current >250A out of RBI 1. Downstream DDCUs experienced a POR . Troubleshooting performed on 10/11/12, with no trip detected.   On 10/17/12, untied channel 3A from 3B with no issues. On 10/18/12, all nominal downstream loads were connected to DCSU 3A. Channel 3A is operating nominally. Based on the observed signatures, the most likely cause of the trip was a component failure within the SSU.

- **Voltage Current Stabilizer (CHT) 21**
  - [CHT21] is currently OFF. MCC-H is NO GO for reactivation. The [CHT] is believed to have caused MBSU2 RBI5 to trip off on GMT 206. The exact mechanism is unclear. Further testing on GMT 234 confirmed that erratic currents and temperatures in the primary power system correlate to [CHT21] operation. Operation has been stable while [CHT21] is deactivated. RSC-Energia and Boeing conducted independent testing in order to attempt to recreate the signature. A [CHT] spare arrived on 49P on 10/31/12. Future [CHT] operations will be discussed at the Bilateral Electrical Working Group (BEWG) TIM starting on 11/5/12.

USOS Challenges (2 of 3)

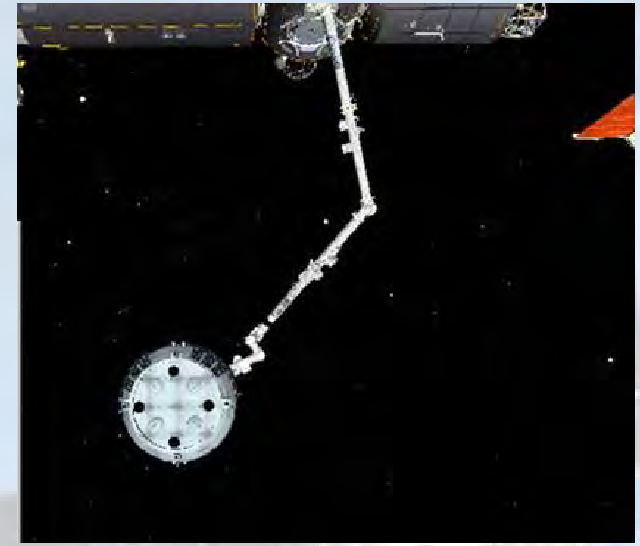
- **Main Bus Switching Unit (MBSU) #1 Replacement During EVAs 18 and 19**
  - Recovered, operating nominally. Bit errors in MBSU1 resulted in effective Loss of Communications (LOC) to MBSU1. The bit errors were due to a known defect in the error correction code of the EEPROM memory chips. Several bit flips had occurred over time and eventually one bit flip caused the loss of comm. MBSU 1 and 2 are the only MBSU's with this flaw. MBSU 2 is currently healthy. MBSU1 was replaced with a spare during EVAs 18 and 19. Removal and installation was difficult because the MBSU is sensitive to misalignment and the ACME bolt interface was galled due to difficult ground installation. The crew lubricated the bolt post interface and drove in a lubricated ACME bolt to chase the threads. The spare MBSU was then installed.
- **Photovoltaic Thermal Control System (PVTCS) 2B Ammonia Leak**
  - Starting in 2007, Channel 2B PVTCS exhibited a relatively constant leak rate of ~1.5 lbm/year. In June 2012, the leak rate increased to somewhere between 5.8 lbm/year and 9.5 lbm/year. EVA 20 was executed on 11/1/12 to substitute the Early External Active Thermal Control System (EEATCS) Photovoltaic Radiators (PVRs) for the P6 2B PVR. The PVR is considered the most likely leak source. Roughly 4 to 6 weeks of operation following the EVA are required to confirm whether the leak has been isolated to the P6 2B PVR. If the leak has not been isolated, another EVA to isolate the Pump Flow Control Subassembly will likely be executed.

USOS Challenges (3 of 3)

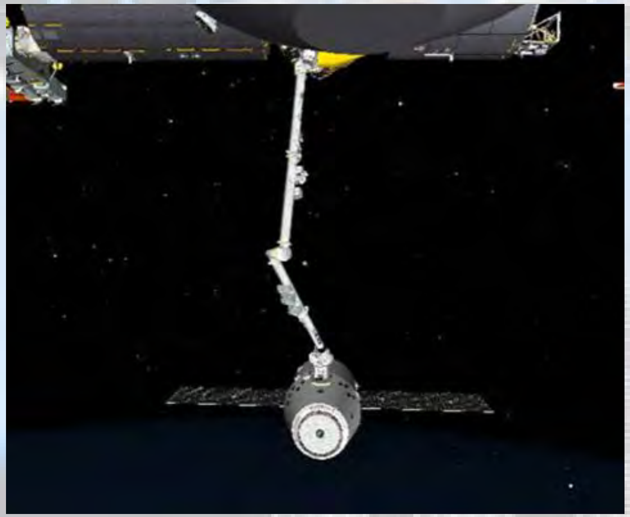
- **RPCM LAP5 1A4A-A RPC 2 FET Hybrid Controller Failure (Lab RWS CEU Power Feed)**
  - Currently troubleshooting. RPCM LAP51A4A-A RPC 2 tripped open on 9/22/12 due to a FET Hybrid Controller Failure. RPC 2 feeds the Lab Robotic Workstation (RWS) Controller Electronics Unit (CEU). Four Spare RPCMs were installed in the LAP5 1A4A-A location. All failed to establish communication with the upstream MDM. Root cause of the failure to establish communication the spares will require further investigation. The original failed RPCM was reinstalled and worked temporarily. However, after another trip of the RPCM on 10/4/12, the crew installed a jumper to power the CEU from RPC 3 on the same RPCM. Subsequent operation has been nominal. Fault tree in work on why comm with other spares installed at this location not successful.
- **EMU 3015 Cooling System**
  - EMU 3015 (EV2) exhibited a cooling anomaly during EVA 18. Late in the EVA, telemetry indicated a degradation of the suit's cooling capability, with sublimator exit temperature trending up from 39'F to 74'F. Per EVA procedures, if a crewmember is not receiving adequate cooling the EVA would be terminated. EV2 reported adequate cooling toward the end of the EVA, so termination was not required. EMU 3015 is NO GO for EVA at this time. The EMU team is investigating the anomaly. The team has developed a fault tree and is working through the branches to determine the cause and to identify corrective actions needed to return EMU 3015 to service. A water sample was obtained from EMU 3015 and returned on SpX-1 to aid in troubleshooting. The three remaining EMUs on ISS are healthy. No issues were observed on EVA 20.

HTV3 Abort Post-release

- **HTV3 performed 1.2 m/sec posigrade abort after release by SSRMS**
  - HTV onboard FDIR detected an off-nominal trajectory that would have caused the HTV to be out of the “corridor” within 300 sec (time to nominal burn)
  - Off-nominal trajectory was due to friction between the SSRMS LEE and the grapple fixture which effectively caused SSRMS to “pull” the HTV during its back-away from the grapple fixture
- **Real-time telemetry and reconstruction of abort post-flight showed no violations of structural or thermal limits**
- **Thermal loads and contamination analysis results have been shared with RSC-Energia specialists**
- **Dragon Departure Analysis**
  - Dragon orientation at release does not require SSRMS to back-away prior to vehicle separation
    - Orbital mechanics pulls Dragon away from SSRMS avoiding the roll seen on HTV 3
  - In case where Dragon does not drift out of SSRMS LEE carriage may provide an impulse to Dragon
    - This case has been analyzed and is bounded by other departure scenarios



HTV Release Configuration



Dragon Release Configuration

USOS System Enhancements

- **Pre-Determined Debris Avoidance Maneuver (PDAM)**
  - New capability that allows ISS to perform a DAM for late notification conjunctions up to Time of Closest Approach (TCA) – 5.5 hrs
  - Software patch uplinked on 8/1/12 allows for Progress on DC1 Nadir PDAM
  - Flight Rule updates and loads analysis is in work to support first demonstration of capability in November 2012
  - Additional capability supporting SM and aft vehicle PDAM planned for SM 8.07 software (early to mid 2013)

- **Obsolescence Driven Avionics Redesign (ODAR)**
  - Integrated Communications Unit (ICU) ready for activation in February 2013, doubling the downlink data rate to 300 Mbps
  - Improved Payload Ethernet Hub Gateway (iPEHG) ready for activation in April 2013 – tenfold increase in medium rate onboard data communications to 100 Mbps
  - 2 flight ICUs and 3 iPEHGs are on-orbit; 3rd flight ICU planned for launch on ATV4; fourth iPEHG launched on SpaceX-1

SpX-1 Anomaly Summary

- **Falcon 9 First Stage Engine Anomaly**
  - Engine 1 was commanded to shutdown during launch
  - Engine 1 experienced a loss of pressure, but was not liberated
  - Falcon 9 continued to operate nominally
  - Dragon vehicle successfully berthed to the ISS
  - SpaceX engine investigation team was formed with NASA participation
    - **Fault tree analysis is underway**
    - **Corrective action to address findings will be applied to future flights**

- **Flight Computer (FC)-B**
  - FC-B de-synced from A and C due to a suspected radiation hit
  - FC-B was rebooted successfully, but not re-synced
  - ISS departure successfully completed with FCs A & C (within flight rules)

- **Other Radiation Events**
  - 1 of 3 GPS units had a suspected radiation hit during free flight and was recovered after a power cycle and reincorporated
  - While berthed, the Propulsion and Trunk computers and Ethernet switch had suspected radiation hits and were also recovered after a power cycle and reincorporated

SpX-1 Anomaly Summary

- **Dragon Draco Thruster Sensor Anomalies**
  - Injector Resistance Temperature Detector (RTD) failure on Draco thruster 4 in quad 3. Sensor not used for any Fault Detection, Isolation, and Recovery (FDIR)
  - Pressure transducer drift in Draco thruster 3 in quad 3. Monitored for continued drift, but did not see any. Two sensor failures are needed to violate the FDIR requirements
  - Pressure transducer failed low in Draco thruster 4 in quad 2. Two sensor failures are needed to violate the FDIR requirements

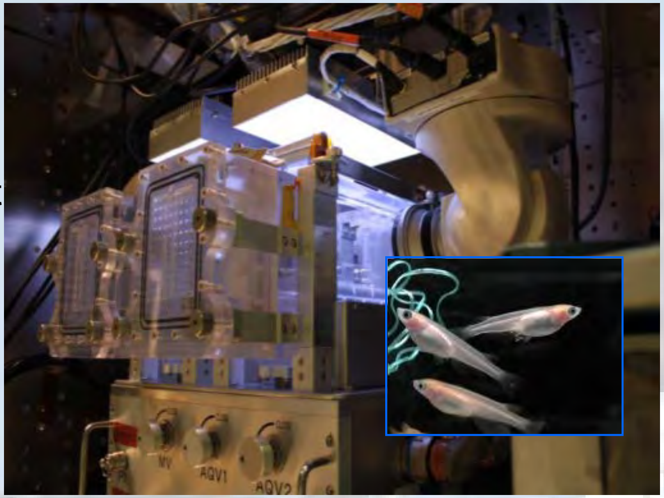
- **Splashdown Anomalies**
  - Dragon lost all 3 coolant pumps after splashdown due to suspected water intrusion. The cabin fan continued to function and it is believed the cabin temperature stayed within limits.
  - When Glacier was accessed (3 hours after splashdown) its temperature was -65 deg C (set point of -95 deg C), indicating a possible loss of power. Glacier data currently under investigation to determine duration and cause of power loss.

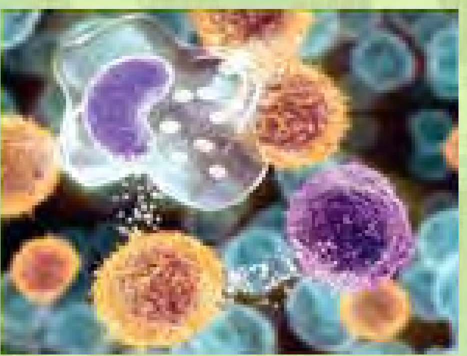
New Research and Recent Results

<u>Medaka Osteoclast:</u>

32 fish delivered on 32S, all systems functioning within the Aquatic Habitat within Kibo module.

- Investigating the bone changes that occur in space through the mult generational breeding of fish will help us understand the impacts to crew health during long-duration flights, and aid in osteoporosis research on Earth.





<u>Micro-6:</u>

A SpaceX-1 Sortie: Studying yeast *(Candida albicans)* for health

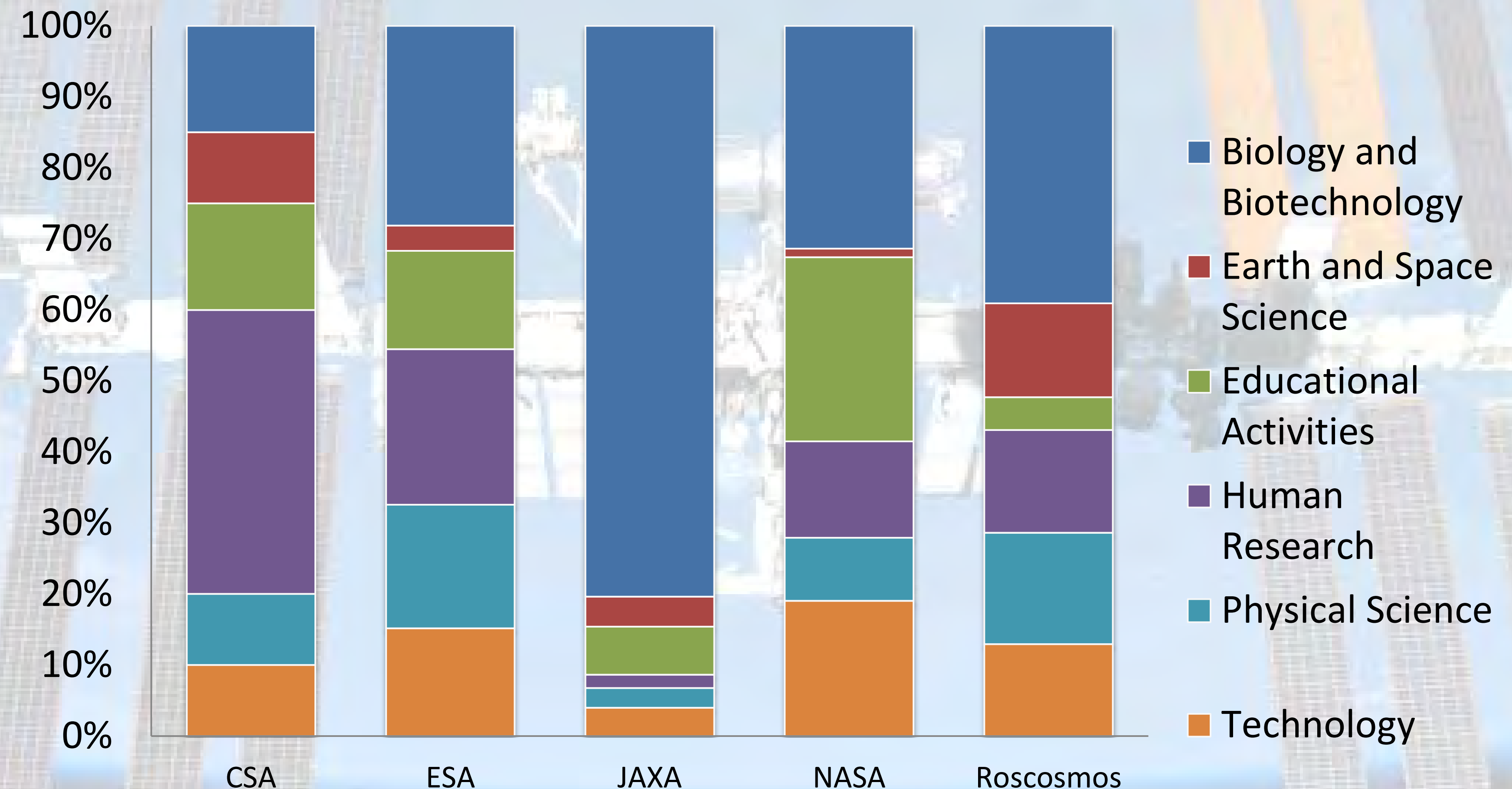
- *C. albicans* exposure to microgravity may result in changes that tell us how this pathogen causes yeast infections on Earth, and help develop improved treatments and prevention.

<u>VO2 MAX:</u>

Final subject in the study completed, marking end of the ISS investigation over 3 years

- VO2 Max evaluates crewmembers' cardiovascular and respiratory fitness by measuring oxygen and carbon dioxide exchange during intense exercise. Subject count required was 12. Fourteen subjects obtained total.

Number of Utilization Investigations
(Expeditions 0-30)

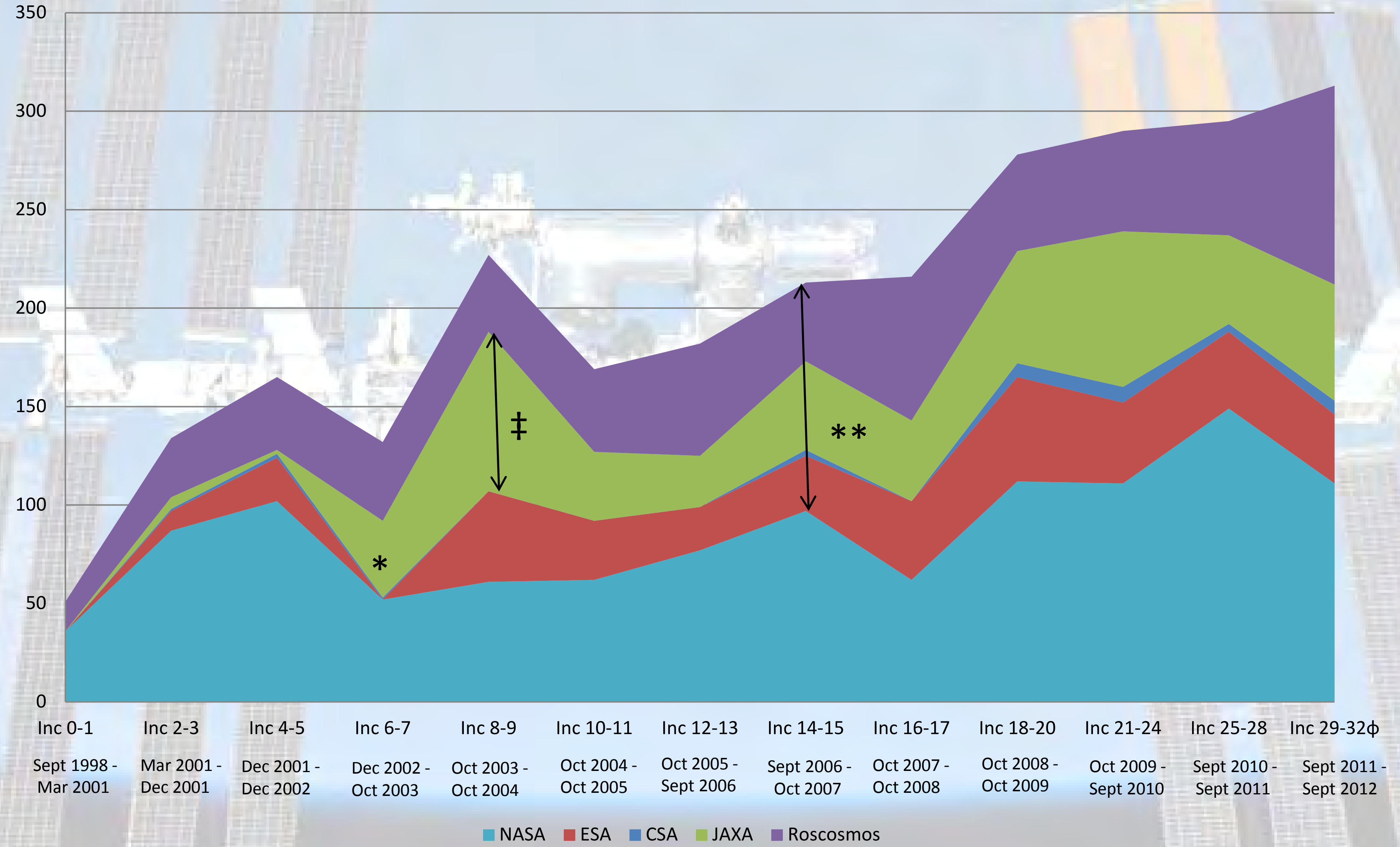


CSA	ESA	JAXA	NASA	Roscosmos
20	224	428	494	325*

*** Estimated**
† Draft

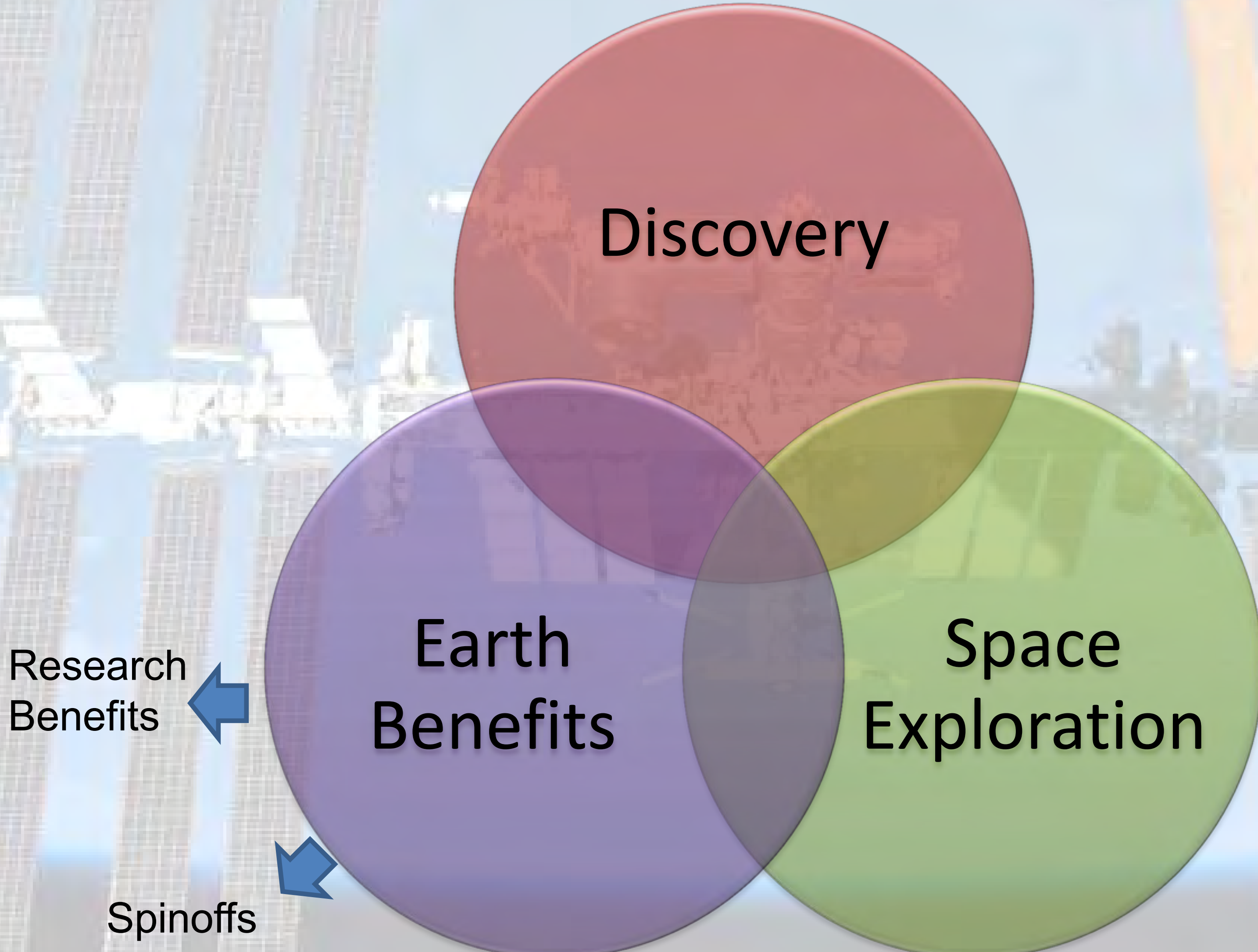
Research and Technology Investigations

(December 1998 - September 2012)



* Post- Columbia ‡ Japanese investigation surge in protein crystal growth ** Shuttle Return to Flight ϕ Estimated Numbers

Benefits of ISS Research



Major ISS Benefits from the Decade of Assembly

Discoveries

- MAXI black hole swallowing star (*Nature*)
- Vision impacts and intracranial pressure (*Opthalmology*)
- Microbial virulence (*Proc. Nat. Acad. Sci.)*

NASA Exploration Mission

- Life support sustaining and reliability
- Success in bone health maintenance resistive exercise (*J. Bone Mineral Res.*)
- Models for Atomic Oxygen erosion in orbit

Results with potential Earth benefit

- Candidate vaccines for Salmonella and MRSA
- Candidate treatment for prostate cancer
- Candidate treatment for Duschenne's muscular dystrophy

Technology Spinoffs

- Robotic assist for brain surgery
- TiO2 for filtering bacteria from the air in daycares
- Remotely-guided ultrasound for maternal care in remote areas

Use of ISS to Prepare for Exploration

All ISS partners are actively conducting exploration preparatory activities on the ISS to prepare for future roles

- ❖ Partners seeking collaboration opportunities which maximize return on investment

Four main focus areas

- ❖ Exploration technology demonstrations
  - ▪ **On-orbit demonstration or validation of planned and candidate technologies**
- ❖ Maturity and reliability demonstrations of critical exploration systems, such as life support systems
  - ▪ **Driving evolution in capabilities supporting the ISS today to meet future challenges - high reliability, high efficiency, low mass, low power**
- ➢ Human health management for long duration space travel
  - ❖ **Research to understand the main risks to human health and performance**
  - ❖ **Validation of strategies for keeping the crew healthy and productive**
- ➢ Operations simulations and techniques demonstrations
  - ❖ **Furthering our understanding of future operations challenges**
  - ❖ **Gaining information which will enable efficient and effective mission design and operations approaches**

Media Outreach Strategy

- **ISS Program Communications Plan**
  - Draft now being incorporated into Agency- and Center-level plans
  - Grass-roots: ISS Ambassadors has reached over 2000 NASA Employees
- **Web and social media**
  - Research stories on nasa.gov had 3.6 million page views in 2012 (down from 8 million in 2011 with last Shuttle flights)
  - 75,000 views of ISS Research Blog entries
  - >22,000 followers of @ISS_Research
- **Traditional media**
  - ~20 press interviews and 7 media events on ISS research in 2012
  - ~5,000,000 Impressions of stories through 24-7 redistribution service
  - SpaceX pre-launch press events on ISS research replace Shuttle pre-launch events

ISS Research Web Resources

- **ISS Research & Technology**
  http://www.nasa.gov/iss-science/

- **@ISS_Research**

- **ISS Research Blog “A Lab Aloft”**
  http://go.usa.gov/atl

- **ISS Benefits for Humanity Direct Link**

www.nasa.gov/mission_pages/station/research/benefits/index.html

One Year Expedition

- **Four Russian cosmonauts have spent 365 days or more in low earth orbit (Mir station)**
  - Vladimir Titov, Musa Manarov 366 days Dec 87 – Dec 88
  - Valery Polyakov 438 days Jan 1994 – Mar 95
  - Sergei Avdeev 380 days Aug 98 – Aug 99
- **Significant advances in habitability, countermeasures, physiologic understanding since then**
  - Also sharper focus on next generation exploration programs
- **Medical and human research infrastructure across ISS Partners enables a robust joint science program around year long flights**
- **Many Human Health and Performance activities facilitate this program**
  - From other side, year long flight program is a forcing function to complete Human Health and Performance objectives

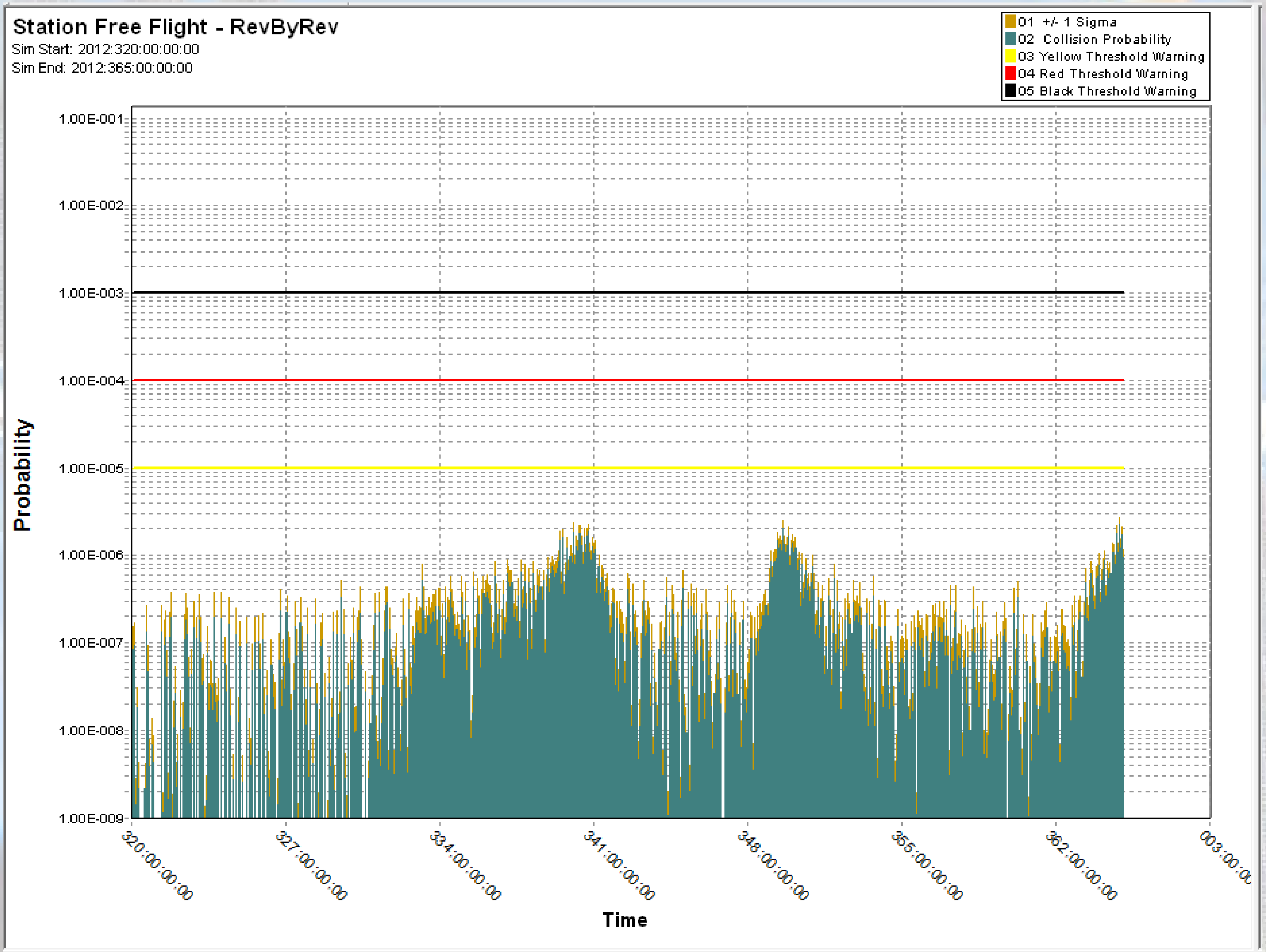
One Year Expedition

- **NASA Human Research Program would realize significant value in one year flights**
- **Investigations and countermeasures data with 6 month flight heritage can be compared more meaningfully with extended durations (the extended time alone becomes the variable)**
- **Operational medical metrics continued beyond 6 months will help identify potential long duration risks and guide research and exploration medical ops**
- **Focus would be on Mars / NEA mission related risks**
- **Validation of physical countermeasures**
    - Bone density and strength, muscle mass and strength, aerobic capacity, postural tolerance – ability of current countermeasures to maintain bone, muscle, fitness for 1 year
- **Look for threshold effects in health and performance metrics beyond 6 months**
- **Serial assessments of vision/intracranial pressure and other microgravity effects**
    - Establish trend of progression vs. plateau effect
- **Three options studied and NASA and the Partners settled on a one year Expedition for one Roskosmos cosmonaut and one NASA astronaut starting in Spring 2015**

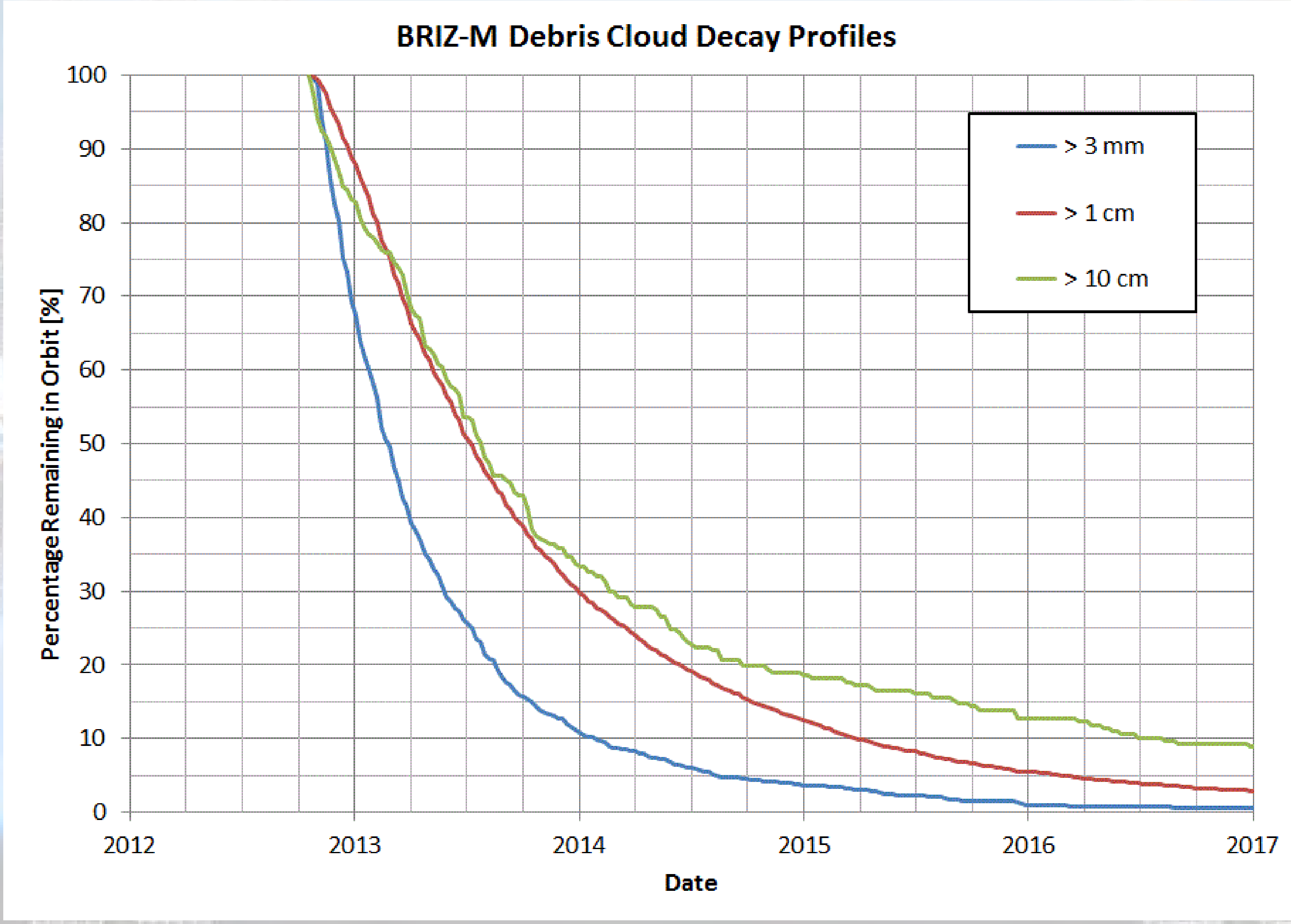
Briz-M Breakup Event

- **On 16 October 2012 a Proton Briz-M upper stage with approximately 10 metric tons of residual propellant exploded.**
    - Stage had malfunctioned soon after launch on 6 August 2012
    - Orbit of stage at time of event: 265 km by 5010 km, 50 degree inclination
    - Dry mass of stage: 2.6 metric tons
- **Initial U.S. Space Surveillance Network assessment of large pieces (~10 cm and greater) was in excess of 700.**
    - 101 debris officially cataloged as of 7 November
- **The estimated initial number of debris posing a potential critical risk to ISS was ~65,000.**
- **~85% of the debris posing a critical risk to ISS is expected to reenter the atmosphere within one year.**

Briz-M ISS Risk Assessment through 2012



Rate of Decay of Briz-M Debris



ISS MMOD Risk Status

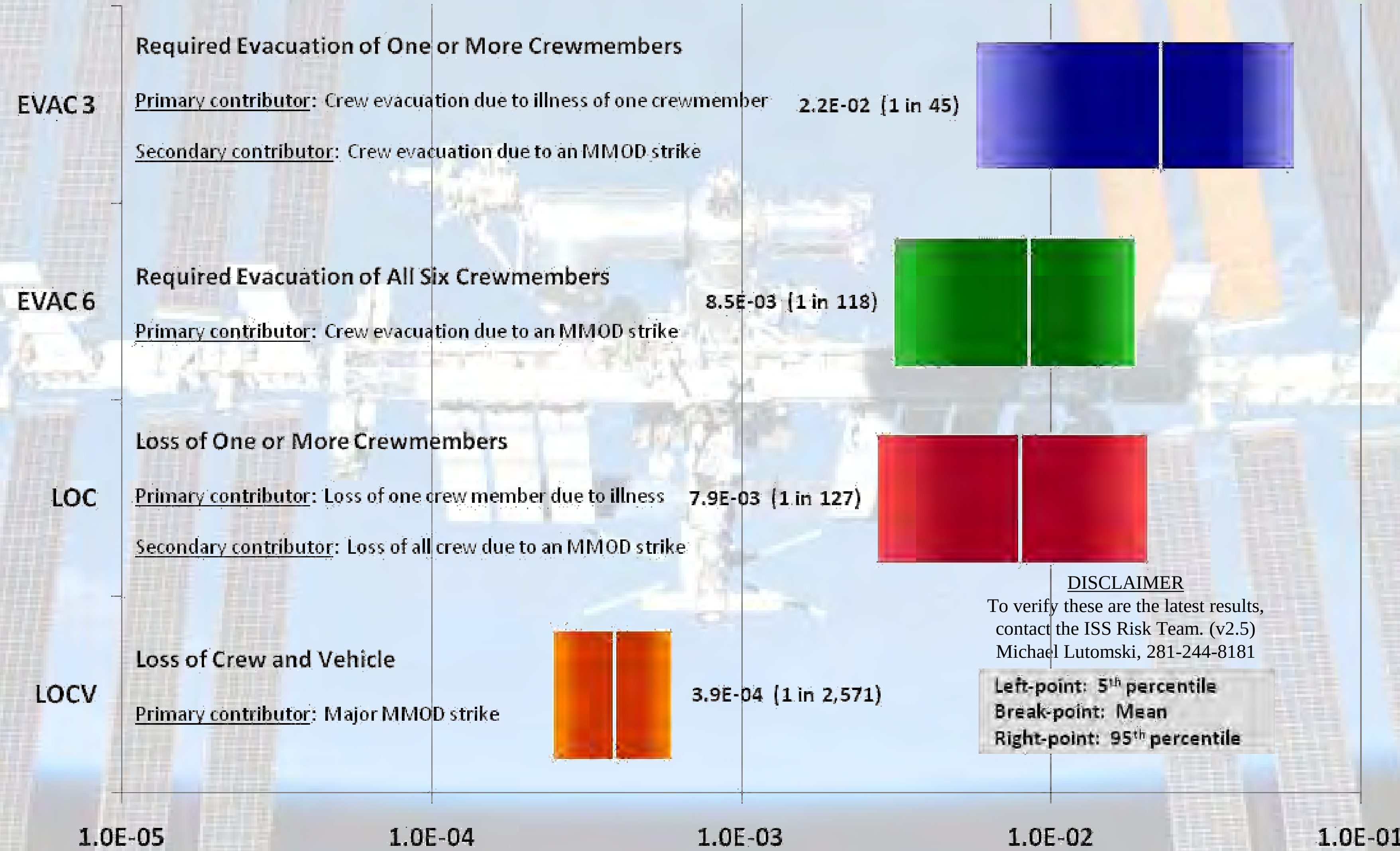
- **The following chart provides a status of ISS micrometeoroid and orbital debris (MMOD) risks**
- **These are 10 year MMOD assessments using the ORDEM 2000 orbital debris model and the MEM meteoroid model**
  - The new debris model, ORDEM 3.0, will be released later in the year, and we will require 6-8 months to evaluate ISS MMOD risks due to modifications to ISS shielding performance equations required to account for steel impactors
- **The assessments are based on using Soyuz and Progress vehicles predominately in future**
  - ATV & HTV included, but US commercial vehicles are not included
  - As commercial crew and cargo vehicles replace Soyuz/Progress vehicles, ISS MMOD risks will improve
- **Briz-M breakup is not included in these numbers**

ISS MMOD Risk Projected for next 10 years

using ORDEM2000 debris model & MEM meteoroid model

ISS MMOD Risks 10-year future time period, updated with latest NASA results documented in JSC-65837 and JSC-66198				
	Date	**Penetration Risk**	**Loss-of-crew (LOC) Risk**	**Evacuation Risk**
Requirement		≤ 24% (PNP=0.76)	≤ 5% (PNCF=0.95)* *Goal, not a requirement	NA
ISS Risk as of March 2012	March 2012	52% (PNP=0.48)	8.0% (PNCF=0.920)	16.1% (PNevac=0.839)
With partial implementation of Progress enhancement beginning with 47P	April 2012	49.0% (PNP=0.510)	7.6% (PNCF=0.924)	14.4% (PNevac=0.856)
With above and Soyuz enhancement beginning with 30S	May 2012	34.5% (PNP=0.655)	5.2% (PNCF=0.948)	14.3% (PNevac=0.857)
Above and 5 SM debris panels installed on RS EVA 31 (Current Configuration)	August 2012	33.9% (PNP=0.661)	5.1% (PNCF=0.949)	13.7% (PNevac=0.863)
Above and full implementation of Progress enhancement beginning with 57P	September 2014	28.0% (PNP=0.720)	4.6% (PNCF=0.954)	11.0% (PNevac=0.890)
Above and commercial crew vehicles beginning in 2017 (reduce Soyuz flights)	2017	26.5% (PNP=0.735)	4.4% (PNCF=0.956)	11.0% (PNevac=0.890)

PRA, V 2.5 Results (6 months)



ISS Top Program Risk Matrix

Post November 09, 2012 PRAB

Risks (L x C) *continued*

Score: 2 x 2
- ▲ 6347 - Temporary Urine and Brine Stowage System Catastrophic leak of a Tox-2 Fluid - (OB) - (C,S,T,Sa)
- ▲ 6198 - ODAR HRCS/ICU Cost Growth - SSCN#11372 - (OD) - (S,T)
- ▲ 6032 - On-Orbit Stowage Short-Fall (Pressurized Volume) - (OC) - (T,Sa)
- ▲ 5184 - USOS Cargo Resupply Services (CRS) Upmass Shortfall - 2010 through 2016 - (ON) - (C,S,T,Sa)

LIKELIHOOD					
5			1	3	1
4			1	5	
3			3	1	2
2		4			
1					
	1	2	3	4	5

CONSEQUENCE

Low	Medium	High	
C – Cost	S – Schedule	T – Technical	Sa – Safety

▲ – Top Program Risk (TPR)

Added: 6404, 6402, 6399, 6393, 6368, 6367, & 6277

Removed: 5456 – ISS Budget & Schedule, 6093 – OGA Functionality, and 6262 – NORS Shortfall

Rescored: 5184 & 6347

Corrective/Preventative Actions

None

Watch Items

None

Continual Improvement

None

Risks (L x C)

Score: 5 x 5
- ▲ 6352 - Overlap in Commercial Crew & Soyuz Launch Services - (OH) - (C,S,T,Sa)

Score: 5 x 4
- ▲ 6370 - ISS Pension Harmonization - (OH) - (C)
- ▲ 6344 - ISS Operations Budget Reduction - (OH) - (C)
- ▲ 6234 - Institutional Gaps (Formally Loss of Constellation funding) - (OH) - (C,S,T,Sa)

Score: 4 x 4
- ▲ 6399 - ISS Budget and Schedule - (OH) - (C,S,T)
- ▲ 6393 - Channel 2B PVTCS Ammonia Leak Increasing - (OB) - (C,S,T,Sa)
- ▲ 6372 - Full ISS Utilization - (OZ) - (S)
- ▲ 6367 - NASA Docking System (NDS) Qualification Cost and Schedule - (OG) - (C,S,T,Sa)
- ▲ 6169 - Visual Impairment / Intracranial Pressure - (SA) - (C,S,T,Sa)

Score: 3 x 5
- ▲ 5688 - ISS Solar Array Management Operations Controls and Constraints - (OM) - (C,S,T,Sa)
- ▲ 2810 - Russian Segment (RS) capability to provide adequate MM/OD protection - (OM) - (C,S,T,Sa)

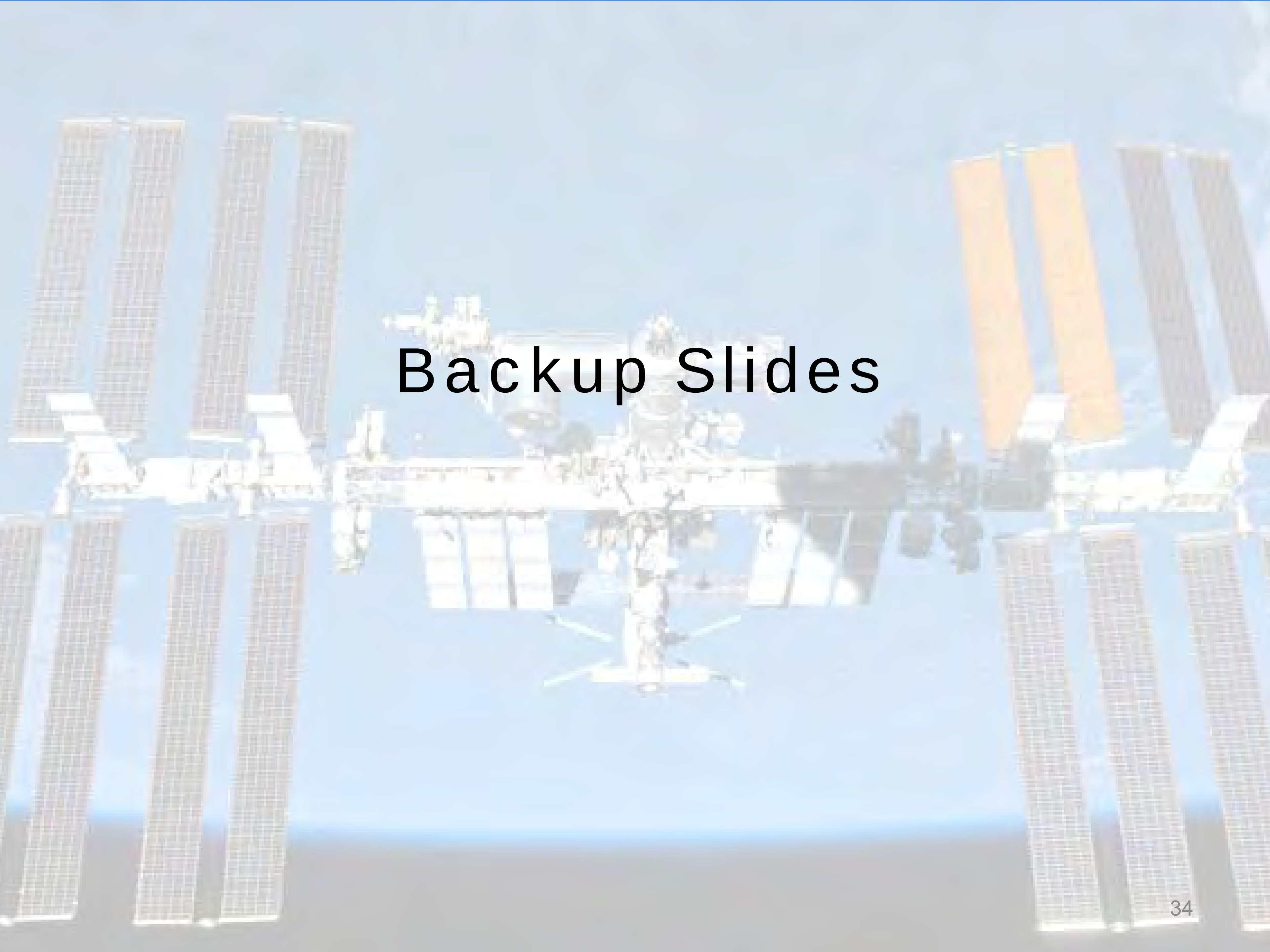
Score: 5 x 3
- ▲ 6402 - SpaceX Dragon splash down - water intrusion / power outage - (ON) - (S,T)

Score: 3 x 4
- ▲ 6404 SpaceX Falcon 9 Engine Failure - (ON) - (S,T)

Score: 4 x 3
- ▲ 5269 - The Big 12 Contingency EVA's - (OB) - (S,T,Sa)

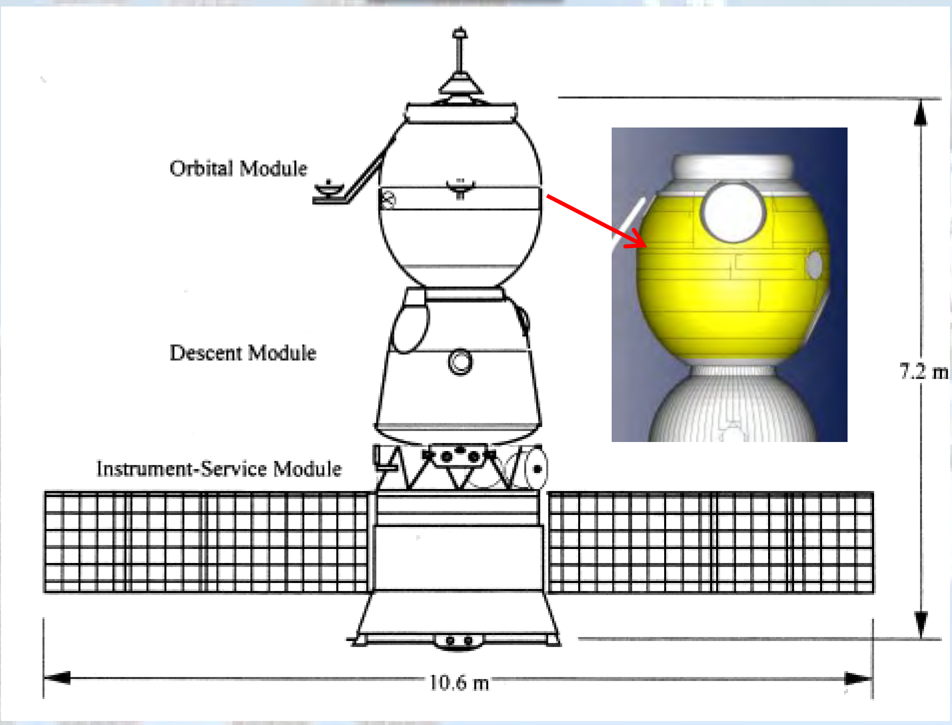
Score: 3 x 3
- ▲ 6368 - Development of ISS On-Orbit Nitrogen and Oxygen Recharge Capability - (OG) - (C,S,T,Sa)
- ▲ 6277 - Loss of utilization flexibility based on CRS capabilities - (OZ)
- ▲ 6096 - Urine Processing Function - (OB) - (C,T)

Backup Slides



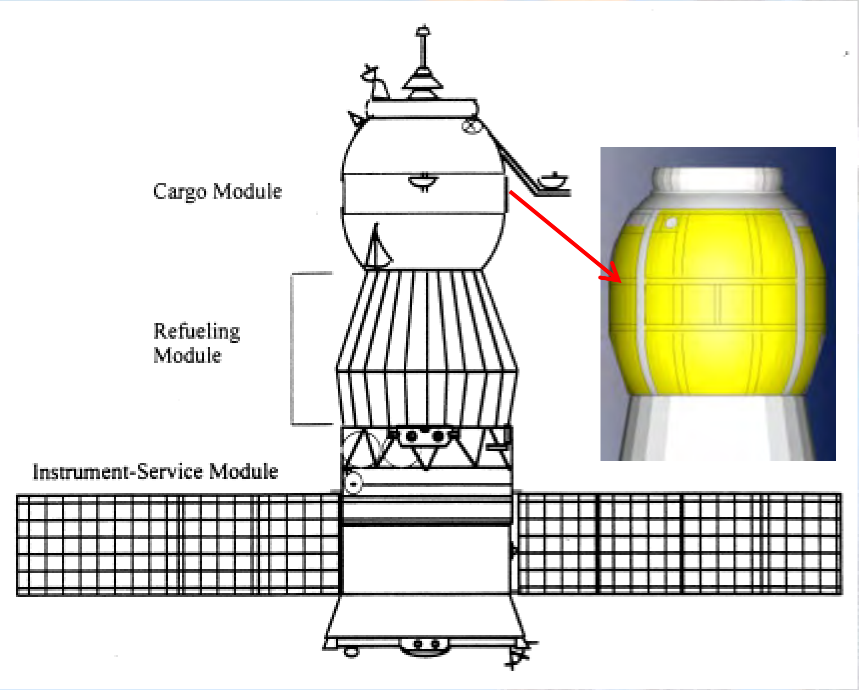
Soyuz & Progress: Enhanced Shielding Region Maps

Soyuz



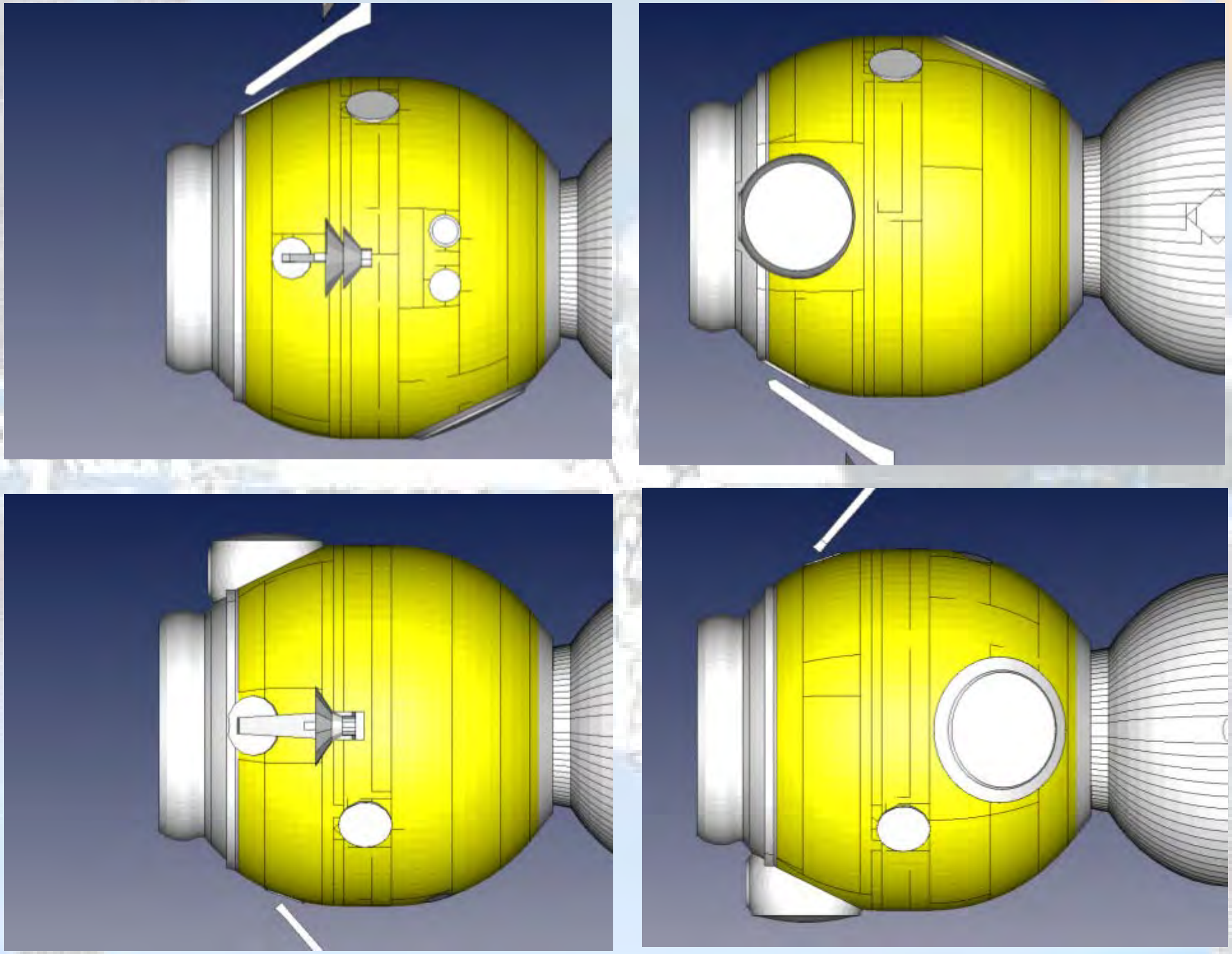
Soyuz Orbital Module
Enhanced MMOD Shielding Area
(yellow region)

Progress



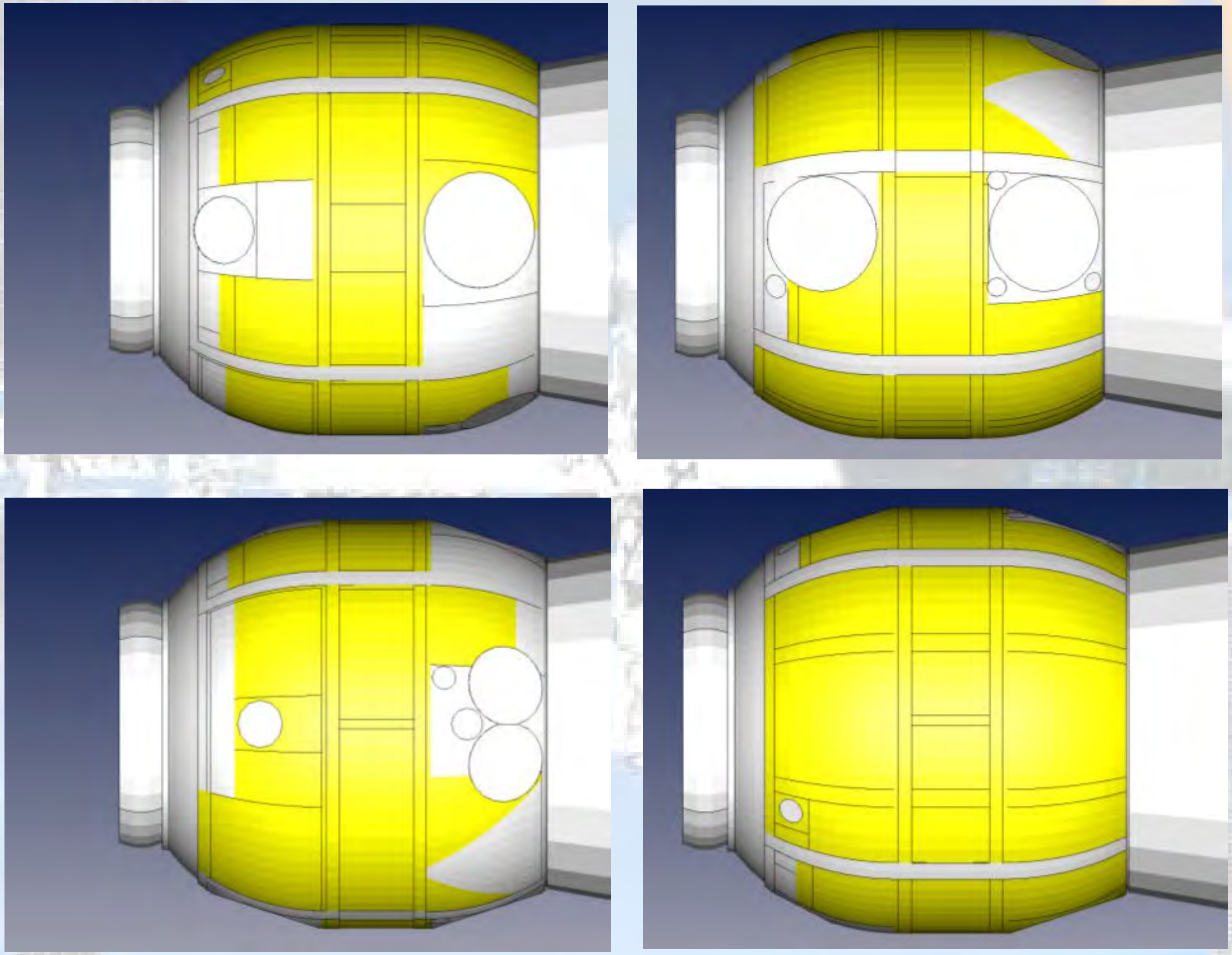
Progress Cargo Module
Enhanced MMOD Shielding Area
(yellow region)

Soyuz Orbital Module
Enhanced Shielding Region Maps



Soyuz Orbital Module
Enhanced MMOD Shielding Area
(yellow regions)

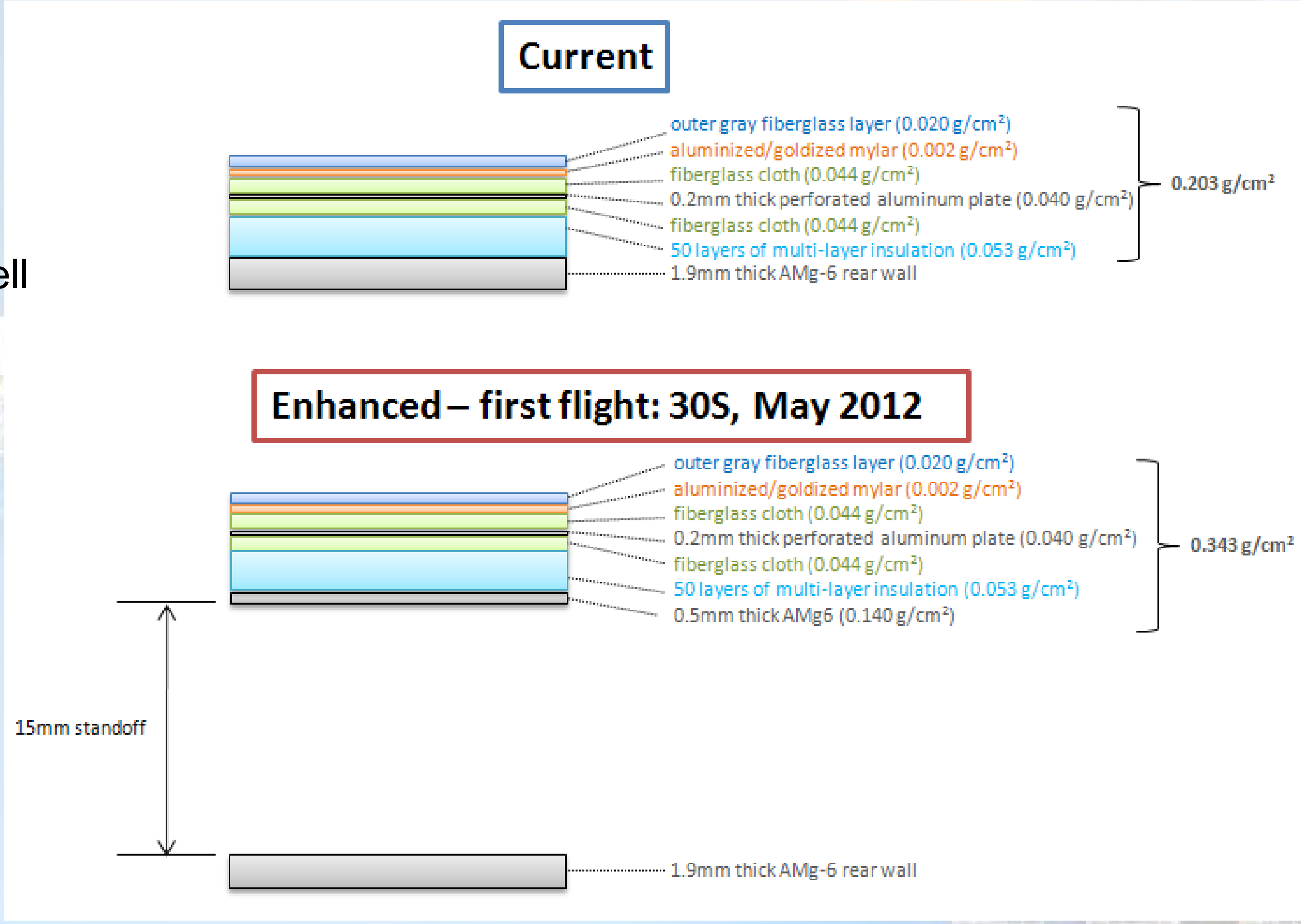
Progress Cargo Module Enhanced Shielding Region Maps



Progress Cargo Module
Enhanced MMOD Shielding Area
(yellow regions)

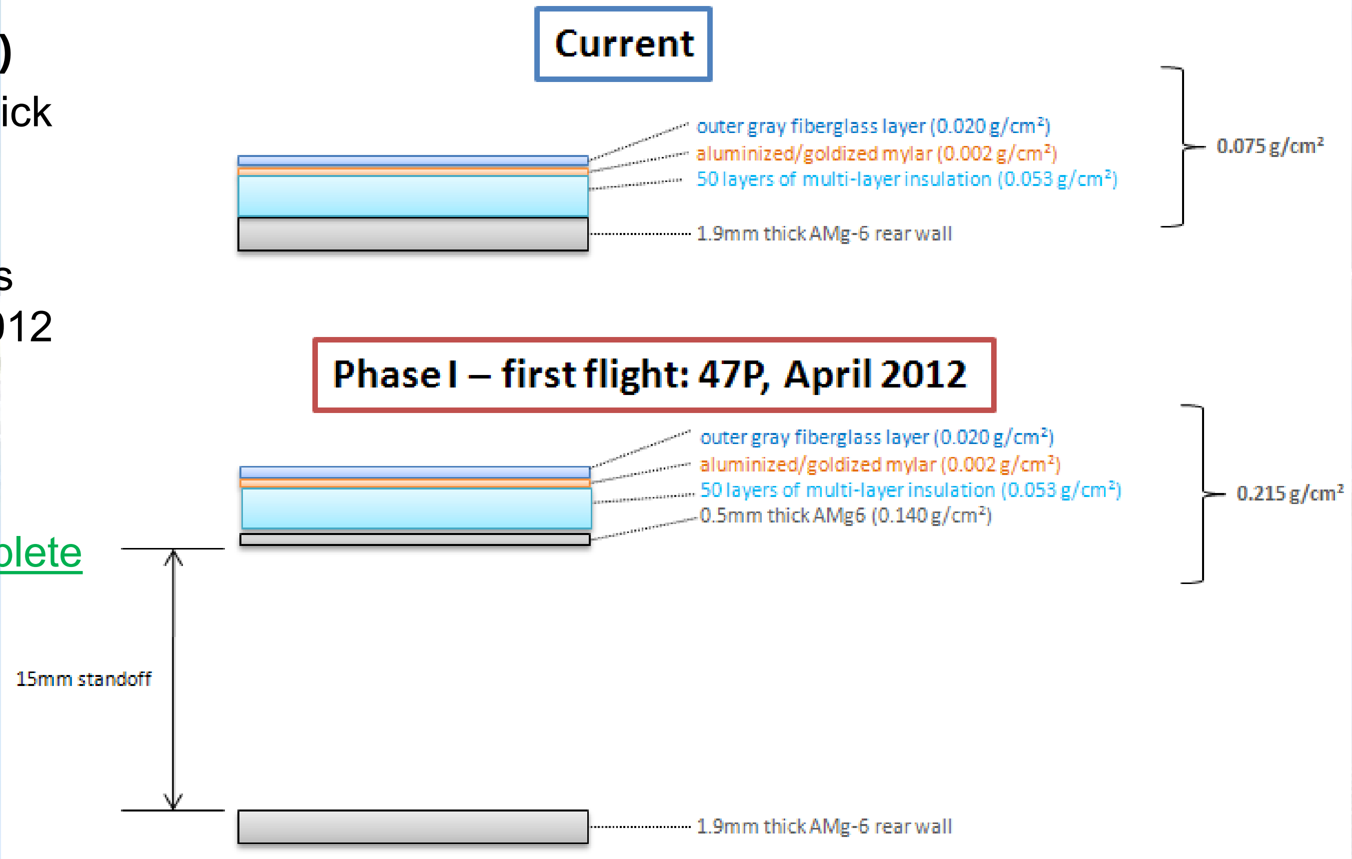
Soyuz Orbital Module MMOD Shield Enhancements

- **Soyuz:**
  - Addition of a 0.5mm thick aluminum bumper at a 15mm distance from the existing Orbital module pressure shell
  - First use on Soyuz flight 30S, 15 May 2012 (vehicle #705)
  - Used on all subsequent Soyuz vehicles
  - **Current Status:** implementation complete



Progress Cargo Module
MMOD Shield Enhancements

- **Progress: (Phase 1 of 2)**
  - Addition of 0.5mm thick bumper and 15mm standoff
  - First use on Progress flight 47P, 20 April 2012 (vehicle #415)
  - **Current Status:** implementation complete



Progress Cargo Module
MMOD Shield Enhancements

- **Progress: (Phase 2 of 2)**
  - Addition of a 0.2mm thick aluminum plate
  - Addition of a fiberglass cloth layer on both sides of the 0.2mm thick aluminum plate
  - First use on Progress flight 57P, September 2014
  - **Current Status**: awaiting implementation